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(71) Applicant: MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.
Kadoma-shi Osaka (JP)

(72) Inventors:
- Horiike, Yoshio
  Shijonawata-Shi, Osaka, 575 (JP)
- Yoshimura, Yasuo
  Yamatokouriyama-Shi, Nara, 639-11 (JP)
- Yokoajiro, Yoshiyuki
  Yamatokouriyama-Shi, Nara, 639-11 (JP)
- Matsumura, Terue
  Ikoma-Gun, Nara, 636 (JP)
- Hasegawa, Makoto
  Kami-Soshigaya, Setagaya-Ku, Tokyo 157 (JP)
- Mimura, Masahiro
  Tokyo, 167 (JP)

(74) Representative: Eisenführ, Speiser & Partner
Martinistrasse 24
28195 Bremen (DE)

(54) **Radio receiver apparatus of orthogonal detection type comprising local oscillator means with improved automatic frequency control arrangement**

(57) In a radio receiver apparatus of an orthogonal detection type, a voltage controlled first local oscillator generates a first local oscillation signal, and mixers mix an inputted reception signal with the first local oscillation signal and a 90° shifted signal thereof, respectively, the mixed signals respectively being passed through first and second band-pass filters to obtain desired first intermediate frequency signals. Further, a second local oscillator generates a second local oscillation signal. Further mixers mixes the first intermediate frequency signals from the first and second band-pass filters with the second local oscillation signal and a 90° shifted signal thereof, respectively. Then there is calculated either one of a sum of and a difference between the resulting mixed signals, the calculated signal being passed through a third band-pass filter to obtain a second intermediate frequency signal to be demodulated. Furthermore, an average frequency detector detects an average frequency of the second intermediate frequency signal for a predetermined time interval, and a frequency correction circuit controls the first local oscillation frequency of the first local oscillation signal based on the detected average frequency.

Fig.2

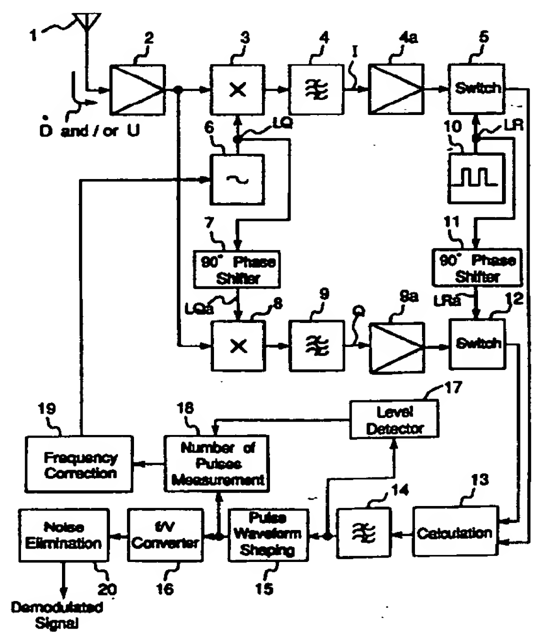

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Fig. 10 shows a local oscillator circuit of a prior art for a frequency modulation (FM) radio receiver apparatus.

Referring to Fig. 10, the local oscillator circuit comprises a time constant circuit 101 and a local oscillator 102. A demodulation signal outputted from a frequency to voltage converter (referred to as an f/V converter hereinafter) 100 functioning as an FM demodulator is inputted to the local oscillator 102 through the time constant circuit 101 comprising a in-series-connected resistance R and a in-parallel-connected capacitor C, and then the demodulation signal is passed through a circuit including a variable capacitance diode VD and a coupling capacitor Cc to a voltage controlled oscillator 103.

In the local oscillator circuit shown in Fig. 10, when the time constant of the time constant circuit 101 is set to a relatively small value, the frequency of the output signal of the local oscillator 103 is deviated or fluctuated due to a relatively low frequency component of the demodulation signal. On the other hand, when the time constant of the time constant circuit 101 is set to a relatively large value, it is possible to reduce of the deviation or fluctuation of the frequency of the local oscillator 103, however, there is such a problem that it takes a long time to complete an automatic frequency control (referred to as an AFC hereinafter) operation from a timing when a power switch is turned on.

SUMMARY OF THE INVENTION

An essential object of the present invention is therefore to provide a radio receiver apparatus comprising a local oscillator with an improved automatic frequency control arrangement.

Another object of the present invention is to provide a radio receiver apparatus comprising a local oscillator with an improved automatic frequency control arrangement, capable of stably controlling the frequency of the local oscillator with an operation time shorter than that of the prior art.

A further object of the present invention is to provide a radio receiver apparatus comprising a local oscillator with an improved automatic frequency control arrangement, capable of stably controlling the frequency of the local oscillator without any influence of a frequency drift of the local oscillation.

In order to achieve the aforementioned objective, according to one aspect of the present invention, there is provided a radio receiver apparatus of an orthogonal detection type, comprising:

voltage controlled first local oscillator means for generating a first local oscillation signal having a first local oscillation frequency, which is changed in response to an inputted voltage;

first phase shifter means for shifting a phase of the first local oscillation signal generated by said first local oscillator means by 90 degrees, and outputting a phase-shifted first local oscillation signal;

first mixer means for mixing an inputted reception signal with the first local oscillation signal generated by said first local oscillator means, and outputting a resulting mixed signal;

first band-pass filter means for passing therethrough a desired first intermediate frequency signal having a predetermined first intermediate frequency in response to the mixed signal outputted from said first mixer means, and outputting the first intermediate frequency signal;

second mixer means for mixing the inputted reception signal with the phase-shifted first local oscillation signal outputted from said first phase shifter means, and outputting another resulting mixed signal;

second band-pass filter means for passing therethrough another desired first intermediate frequency signal having the first intermediate frequency in response to the mixed signal outputted from said second mixer means, and outputting another first intermediate frequency signal;

second local oscillator means for generating a second local oscillation signal having a second local oscillation frequency;

second phase shifter means for shifting a phase of the second local oscillation signal generated by said second local oscillator means by 90 degrees, and outputting a phase-shifted second local oscillation signal;

third mixer means for mixing the first intermediate frequency signal outputted from said first band-pass filter means with the second local oscillation signal outputted from said second local oscillator means, and outputting a resulting mixed signal;

fourth mixer means for mixing the another first intermediate frequency signal outputted from said second band-pass filter means with the phase-shifted second local oscillation signal outputted from said phase shifter means, and outputting a further resulting mixed signal;

calculation means for calculating either one of a sum of and a difference between the resulting mixed signal outputted from said third mixer means and the further resulting mixed signal, and outputting a signal representing a resulting calculated result thereof;

third band-pass filter means for passing therethrough a second intermediate frequency signal having a center frequency which is apart from the second local oscillation frequency by a difference frequency between a frequency of the inputted reception signal and the first local oscillation frequency, in response to the signal outputted from said calculation means, and outputting the second intermediate frequency signal;

demodulation means for demodulating the second intermediate frequency signal outputted from said third band-pass filter means, and outputting a resulting demodulated signal;

Fig. 2 is a block diagram of a radio receiver apparatus of an orthogonal detection type according to a first preferred embodiment of the present invention;

Fig. 3 is a block diagram of a radio receiver apparatus of an orthogonal detection type according to a second preferred embodiment of the present invention;

Fig. 4 is a block diagram of a radio receiver apparatus of an orthogonal detection type according to a third preferred embodiment of the present invention;

Fig. 5 is a block diagram of switch circuits 5 and 12 shown in Figs. 2, 3 and 4;

Fig. 6 is a block diagram of a second local oscillator 10 and a 90° phase shifter 11 shown in Figs. 2, 3 and 4;

Fig. 7 is a block diagram of a frequency to voltage converter 16 shown in Figs. 2, 3 and 4;

Fig. 8 is a timing chart showing an operation of the frequency to voltage converter 16 shown in Fig. 7;

Fig. 9 is a timing chart showing an operation of the switch circuits 5 and 12 shown in Fig. 5;

Fig. 10 is a local oscillator circuit of a prior art;

Fig. 11 is a block diagram of a level detector 17 and a number of pulses measurement circuit 18 shown in Fig. 2;

Fig. 12 is a block diagram of a time interval measurement circuit 22 shown in Fig. 3;

Fig. 13 is a block diagram of a modified switch circuit of a further preferred embodiment; and

Fig. 14 is a block diagram of another modified switch circuit of a still further preferred embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments according to the present invention will be described below with reference to the attached drawings.

FIRST PREFERRED EMBODIMENT

Fig. 2 shows a radio receiver apparatus of an orthogonal detection type according to a first preferred embodiment of the present invention.

Referring to Fig. 2, a radio signal is received by an antenna 1, and the received radio signal is inputted through a high-frequency low-noise amplifier 2 to a mixer 3 and another mixer 8.

In the preferred embodiment, the desired radio signal D to be received by the antenna 1 is expressed by the following equation (1):

$$D = \cos(\omega + \Delta\omega) \cdot t \qquad (1),$$

where ω is an angular frequency of a carrier wave, and $\Delta\omega$ is an angular frequency deviation having both positive and negative polarities. The angular frequency deviation $\Delta\omega$ changes in time depending on data or a speech signal, namely, a carrier wave signal of the desired radio signal D is modulated at a transmitter according to data or a speech signal to be transmitted. In other words, the desired radio signal D is a frequency-modulated signal, i.e., FM signal. In the case of data to be transmitted, the desired radio signal D is an FSK signal. Please note that the angular frequency ω of the carrier wave signal is the center frequency of the desired signal D.

A voltage controlled first local oscillator 6 generates a sine-wave first local oscillation signal LQ expressed by the following equation (2) and then outputs the first local oscillation signal LQ to the mixer 3 and the 90° phase shifter 7:

$$LQ = \cos(\omega + x) \cdot t \qquad (2),$$

where "x" represents an angular shift frequency from the angular frequency ω of the carrier wave signal, and is the first intermediate frequency in the present preferred embodiment. In a 90° phase shifter 7, the phase of the signal LQ outputted from the local oscillator 6 is shifted by 90 degrees, and then the 90° phase shifter 7 outputs a phase-shifted first local oscillation signal $LQa = \sin(\omega + x) \cdot t$ to the mixer 8.

Consequently, there are respectively generated following signals by the mixers 3 and 8;

(a) Output of the mixer 3:

$$D \times LQ = \cos(\Delta\omega - x) \cdot t \qquad (3),$$

and

(b) Output of the mixer 8:

$$D \times LQa = \sin(\Delta\omega - x) \cdot t \qquad (4).$$

In the preferred embodiment, since such a condition of $(r + x) > |\Delta\omega|$ is set as described above, the phase of the equation (10) is always positive in the positive time. In other words, no negative frequency is generated in the preferred embodiment. Therefore, as is apparent from the above-mentioned equation (10), the output signal outputted from the third band-pass filter 14 can be regarded as such a frequency-modulated signal obtained when the carrier wave signal having an angular frequency of $(r + x)$ is frequency-modulated with a frequency deviation of $\Delta\omega$, wherein the angular frequency $(r + x)$ is the second intermediate frequency in the present preferred embodiment. Therefore, the above-mentioned frequency-modulated signal outputted from the third band-pass filter 14 can be demodulated by a f/V converter 16 which generates an output voltage proportional to the frequency of the inputted signal.

In the preferred embodiment, the signal outputted from the third band-pass filter 14 is inputted through a pulse waveform shaping circuit 15 for shaping the waveform of the inputted signal into a pulse waveform to the f/V converter 16. Further, a noise elimination process is performed on a demodulated signal outputted from the f/V converter 16 by a noise elimination circuit 20 for removing pulse noises which may be caused due to the FM demodulation in the FM demodulation process of the f/V converter 16, and thereafter, the processed demodulated signal is outputted from the noise elimination circuit 20.

Since the third band-pass filter 14 has a relatively low band-pass center frequency of about 22.25 kHz, the band-pass filter 14 can be easily implemented by a monolithic IC. Further, the other devices or circuits handle such low frequencies, and therefore the other devices or circuits can be implemented by monolithic ICs.

In the case where the following undesired interference signal U is received by the antenna 1:

$$U = \cos(\omega + 2x + \Delta\omega) \cdot t \qquad (11).$$

Then, there are generated in the radio receiver apparatus shown in Fig. 2, the I and Q signals, respectively, expressed by the following equations:

(a) I signal :

$$U \times LQ = \cos(\Delta\omega + x) \cdot t \qquad (12),$$

and

(b) Q signal :

$$U \times LQa = \sin(\Delta\omega + x) \cdot t \qquad (13).$$

The above interference signals are generated within the same bandwidth of the band-pass filters 4 and 9, as those of the desired signals in the I and Q signals, and therefore, the undesired interference signal can not be removed by the first and second band-pass filters 4 and 9. However, in this case, the calculation circuit 13 outputs the following signal:

$$\cos[\{(r - x) - \Delta\omega\} \cdot t] - (1/3) \cdot \cos[\{(3 \cdot r + x) + \Delta\omega\} \cdot t] + ... \qquad (14).$$

The frequency band of the undesired interference signal U expressed by the equation (14) is obviously different from the frequency band of the desired signal D expressed by the above-mentioned equation (9). Therefore, the signal of the above equation (14) generated due to the undesired interference signal is removed by the third band-pass filter 14 which is designed so as to pass only the signal around the center frequency $(r + x) = 22.25$ kHz therethrough, and then, consequently no undesired interference signal is generated in the output terminal of the third band-pass filter 14.

In above-mentioned preferred embodiment of the present invention, it has been described that the I and Q signals have the same signal level. However, when there is a difference between the signal levels of the I and Q signals due to a variation of circuits, there is generated at the output terminal of the calculation circuit 13, a signal having the same frequency band as that expressed by the above-mentioned equation (9) due to the undesired interference signal U. In view of the above, by providing a level adjustment circuit or level attenuator (not shown) for adjusting the signal levels of the I and Q signals so as to cancel the undesired interference signal component generated within the frequency band expressed by the above-mentioned equation (9), there can be constructed a receiver apparatus less susceptible to the interference. In stead of such a level attenuator, there may be provided a gain-adjustable intermediate frequency amplifier 4a or 9a as the intermediate frequency amplifier 4a or 9a.

Further, depending on the switch construction of the first and second switch circuits 5 and 12, a signal component having an angular frequency "r" may be caused in the output terminals of the switch circuits 5 and 12. In the above-mentioned case, as shown in Fig. 13, the rectangular-wave second local oscillation signal outputted from the second local oscillator 10 may be added by an adder circuit 140 through a level attenuator 141 to the output signal of the first switch circuit 5 or the second switch circuit 12 so as to cancel the signal component having the angular frequency "r".

therebetween. Then, the control voltage controls the oscillation frequency of the first local oscillator 6, and then the average frequency of a second intermediate frequency signal outputted from the third band-pass filter 14 is made to be approximately 16 kHz.

The above-mentioned frequency correction operation will be described in more detail below.

Here is now considered a case where the oscillation frequency of the first local oscillator 6 is shifted by 3 kHz from the frequency of the carrier wave signal of the FSK modulation or FM signal received by the antenna 1. In this case, the center frequency of the second intermediate frequency signal outputted from the third band-pass filter 14 is shifted by 3 kHz from 16 kHz to become 19 kHz. The number of pulses measurement circuit 18 measures the 19-kHz second intermediate frequency signal pulses for 10 milliseconds, and therefore 190 pulses may be counted. On the other hand, a reference number of pulses of 160 pulses is stored in this case, and therefore a difference of 30 is generated by the frequency correction circuit 19, which then generates and outputs a DC voltage corresponding to the difference of 30 through a digital to analogue conversion process to the first local oscillator 6, thereby controlling the first local oscillator 6 so that the center frequency of the second intermediate frequency signal outputted from the third band-pass filter 14 becomes approximately 16 kHz.

In the present preferred embodiment, the pulse waveform shaping circuit 15 and the time interval measurement circuit 22 constitute an average frequency detecting circuit for detecting an average frequency of the second intermediate frequency signal outputted from the third band-pass filter 14.

In the case of an FSK radio receiver apparatus, the radio receiver apparatus is intermittently turned on for a short time of about 20 milliseconds at a predetermined interval, e.g., a time interval of 30 seconds. When no high-level signal is generated from the level detector 17 while the power is supplied to the radio receiver apparatus, it is determined that no signal is transmitted from the other party for communications, and the supply of power is stopped for the next time interval of 30 seconds. When the high-level signal is generated by the level detector 17, the supply of power is continued, and the number of pulses measurement circuit 18 measures the number of pulses. The above-mentioned technique is to operate the FSK radio receiver apparatus using a battery for a relatively long time.

The synchronizing operation of transmission and reception of the FSK signal with the other party of communications performed every 30 seconds can be achieved in such a manner that one party surely transmits the FSK signal every 10 minutes, and the other party receives the transmitted radio FSK signal to synchronize the clock with that of the party which transmits the FSK signal. For the above-mentioned purpose, it is possible to perform the level detection at a signal portion or signal interval modulated with a bit synchronization signal in the FSK modulation signal from the other party for communications and to count the number of pulses.

It is to be noted that the frequency correction circuit 19 can be simply implemented by, for example, a storage unit for storing the reference number of pulses and a microcomputer having a digital to analogue conversion function.

Fig. 7 shows an exemplified construction of the f/V converter 16.

Referring to Fig. 7, the f/V converter 16 comprises an edge detector 42, a monostable multivibrator 43 and a low-pass filter 44. The pulse signal outputted from the pulse waveform shaping circuit 15 is inputted to the edge detector 42.

Fig. 8 shows a timing chart of respective signals Sa, Sb, Sc and Sd shown in Fig. 7, wherein Sa denotes the pulse signal outputted from the pulse waveform shaping circuit 15 to the edge detector 42, Sb denotes a signal is inputted from the edge detector 42 to the monostable multivibrator 43, Sc denotes a pulse signal inputted from the monostable multivibrator 43 to the low-pass filter 44, and Sd is a signal outputted from the low-pass filter 44 to the noise elimination circuit 20.

Referring to Figs. 7 and 8, a leading edge of the inputted intermediate frequency pulse Sa is detected by the edge detector 42, which then outputs a impulse signal representing the timing of the leading edge of the signal Sa to the monostable multivibrator 43. The detected leading edge represented by the impulse signal Sb activates the monostable multivibrator 43, which then outputs a pulse signal Sc having a constant pulse width to the low-pass filter 44. Thereafter, the low-pass filter 44 performs a low-pass filtering process on the inputted pulse signal Sc to output a frequency-to-voltage-converted or demodulated signal.

The signal outputted from the monostable multivibrator 43 is a pulse signal having the same frequency as that of the intermediate frequency pulse signal Sa outputted from the pulse waveform shaping circuit 15. Therefore, the circuit covering up to the monostable multivibrator 43 is regarded as the pulse waveform shaping circuit 15, and then the output signal from the monostable multivibrator 43 can be inputted to the number of pulses measurement circuit 18 shown in Fig. 2 or a time interval measurement circuit 22 shown in Fig. 3 which will be described in detail later.

Although the above has described that the edge detector 42 detects only the leading edge of the second intermediate frequency signal Sa, the present invention is not limited to this. The detector may detect both the leading edge and the trailing edge of the second intermediate frequency signal Sa. In this case, the output frequency of the monostable multivibrator 43 is twice as high as that of the second intermediate frequency signal Sa. Therefore, when the circuit covering up to the monostable multivibrator 43 is regarded as the pulse waveform shaping circuit 15, it is required to change operation constants such as the reference number of pulses and the number of pulses, with respect to the pulses measurement circuit 18, the time interval measurement circuit 22, and the frequency correction circuit 19, taking into consideration the fact that the frequency is doubled.

Fig. 12 shows a composition of the time interval measurement circuit 22 shown in Fig. 3. Referring to Fig. 12, the time interval measurement circuit 22 comprises a counter 130, a 10 milliseconds timer 131, and a latch circuit 132. The high-level signal outputted from the level detector 17 is inputted to an enable input terminal ENABLE of the counter 130, whereas the pulse signal outputted from the pulse waveform shaping circuit 15 is inputted to a clock input terminal CLOCK of the counter 130.

When the output signal from the level detector 17 becomes a high level, the counter 130 is started to count the pulses outputted from the pulse waveform shaping circuit 15. Thereafter, the counter 130 has counted 160 pulses, and then generates and outputs a carry signal to the latch circuit 132. On the other hand, the timer 131 is activated to be started to count a time interval having been passed from a timing when the output signals from the level detector 17 becomes a high level so as to output data representing the counted time to the latch circuit 132. When the counter 130 generates the carry signal, the time data is latched by the latch circuit 132, and then is outputted to the frequency correction circuit 19.

In the present preferred embodiment, upon detecting the fact that an FSK modulation signal is inputted to the antenna 1, the level detector 17 outputs the high-level signal. The high-level signal activates the counter 130 and the timer 131 of the time interval measurement circuit 22. Then the counter 130 counts or measures a time interval from a timing when the counter 130 is activated to a timing when the number of pulses of the second intermediate frequency signal reaches, for example, 160. When the center frequency of the second intermediate frequency signal is 16 kHz, the time interval measured by the counter 130 is 10 milliseconds. When the center frequency of the second intermediate frequency signal is 19 kHz, the time interval measured by the timer 131 of time interval measurement circuit 22 is 8.42 milliseconds.

The time data measured by the timer 131 of the time interval measurement circuit 22 is inputted through the latch circuit 132 to the frequency correction circuit 19. The frequency correction circuit 19, which stores a predetermined reference time interval of 10 milliseconds, calculates a time difference between the reference time interval and the inputted time data. When the inputted time data is 10 milliseconds, the time difference is zero, and therefore no frequency correction operation is performed. On the other hand, when the inputted time data is 8.42 milliseconds, the time difference is 1.58 milliseconds, and therefore a control voltage corresponding to 1.58 milliseconds is outputted. Then the oscillation frequency of the first local oscillator 6 is controlled so that the frequency of the second intermediate frequency signal outputted from the third band-pass filter 14 is made to be approximately 16 kHz in response to the control voltage outputted from the frequency correction circuit 19.

An advantageous effect of the preferred embodiment shown in Fig. 3 is that the measurement accuracy of the center frequency of the second intermediate frequency signal outputted from the third band-pass filter 14 can be improved to allow the frequency correction operation to be performed more accurately by increasing the accuracy of the timer 131 included in time interval measurement circuit 22.

The above-mentioned other modifications in the first preferred embodiment can be applied to the second preferred embodiment, and the other advantageous effects in the first preferred embodiment can be obtained also in the second preferred embodiment.

THIRD PREFERRED EMBODIMENT

Fig. 4 shows a composition of a radio receiver apparatus of an orthogonal detection type according to a third preferred embodiment of the present invention. The present preferred embodiment of the present invention will be described below with reference to Fig. 4.

In Fig. 4, components having the same functions as those of the components shown in Fig. 2 are denoted by the same reference numerals. The present preferred embodiment of the present invention shown in Fig. 4 differs from the preferred embodiment of the present invention shown in Fig. 2, in that there is provided in the third preferred embodiment, an average voltage detector 23 for detecting a voltage output corresponding to the frequency of the second intermediate frequency signal in the f/V converter 16, averaging the detected voltage for a predetermined interval, and outputting the resulting average voltage data, instead of the number of pulses measurement circuit 18 shown in Fig. 2.

In the present preferred embodiment, the f/V converter 16 and the average voltage detector 23 constitute an average frequency detection circuit for detecting an average frequency of the second intermediate frequency signal outputted from the third band-pass filter 14.

Upon detecting the fact that an FSK modulation signal is inputted to the antenna 1, the level detector 17 outputs the high-level signal. The high-level signal activates the average voltage detector 23. The average voltage detector 23 averages the voltage for, for example, 10 milliseconds from a timing when the average voltage detector 23 is activated. On the other hand, the f/V converter 16 outputs a voltage proportional to the frequency of the inputted signal from the pulse waveform shaping circuit 15. For example, when the frequency of the intermediate frequency of the signal inputted to f/V converter 16 is 16 kHz, the output of the f/V converter 16 changes by 0.1 volts every time when the frequency changes by 1 kHz. Therefore, when the frequency of the intermediate frequency is 19 kHz, an output voltage of 1.3 volts is generated and outputted from the f/V converter 16. The voltage data averaged by the average voltage detector 23 is

the gas meter, there is required a small size radio receiver apparatus which can operate on a battery for about ten years.

In a radio type remote control apparatus for use in a residential facility system, such as a remote control apparatus for wirelessly connecting a gas hot-water supply apparatus with a kitchen, being not limited to the automatic meter inspection system, the small size and the battery based operation are indispensable conditions.

The present invention can provide a radio receiver apparatus very effective in regard to the above-mentioned problem.

Although the present invention has been fully described by way of example with reference to the accompanying drawings, it is to be noted here that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present invention as defined by the appended claims, they should be construed as included therein.

Claims

1. A radio receiver apparatus of an orthogonal detection type, comprising:

   voltage controlled first local oscillator means for generating a first local oscillation signal having a first local oscillation frequency, which is changed in response to an inputted voltage;

   first phase shifter means for shifting a phase of the first local oscillation signal generated by said first local oscillator means by 90 degrees, and outputting a phase-shifted first local oscillation signal;

   first mixer means for mixing an inputted reception signal with the first local oscillation signal generated by said first local oscillator means, and outputting a resulting mixed signal;

   first band-pass filter means for passing therethrough a desired first intermediate frequency signal having a predetermined first intermediate frequency in response to the mixed signal outputted from said first mixer means, and outputting the first intermediate frequency signal;

   second mixer means for mixing the inputted reception signal with the phase-shifted first local oscillation signal outputted from said first phase shifter means, and outputting another resulting mixed signal;

   second band-pass filter means for passing therethrough another desired first intermediate frequency signal having the first intermediate frequency in response to the mixed signal outputted from said second mixer means, and outputting another first intermediate frequency signal;

   second local oscillator means for generating a second local oscillation signal having a second local oscillation frequency;

   second phase shifter means for shifting a phase of the second local oscillation signal generated by said second local oscillator means by 90 degrees, and outputting a phase-shifted second local oscillation signal;

   third mixer means for mixing the first intermediate frequency signal outputted from said first band-pass filter means with the second local oscillation signal outputted from said second local oscillator means, and outputting a resulting mixed signal;

   fourth mixer means for mixing the another first intermediate frequency signal outputted from said second band-pass filter means with the phase-shifted second local oscillation signal outputted from said phase shifter means, and outputting a further resulting mixed signal;

   calculation means for calculating either one of a sum of and a difference between the resulting mixed signal outputted from said third mixer means and the further resulting mixed signal, and outputting a signal representing a resulting calculated result thereof;

   third band-pass filter means for passing therethrough a second intermediate frequency signal having a center frequency which is apart from the second local oscillation frequency by a difference frequency between a frequency of the inputted reception signal and the first local oscillation frequency, in response to the signal outputted from said calculation means, and outputting the second intermediate frequency signal;

   demodulation means for demodulating the second intermediate frequency signal outputted from said third band-pass filter means, and outputting a resulting demodulated signal;

   average frequency detection means for detecting an average frequency of the second intermediate frequency signal outputted from said third band-pass filter means for a predetermined time interval; and

   frequency correction means for controlling the first local oscillation frequency of the first local oscillation signal generated by said first local oscillator means so that a difference between the average frequency detected by said average frequency detection means and a predetermined frequency corresponding to a center frequency of the second intermediate frequency signal becomes substantially zero.

2. The radio receiver apparatus as claimed in Claim 1,

   wherein said average frequency detection means comprises:

   pulse waveform shaping means for converting the second intermediate frequency signal into a pulse signal and outputting the pulse signal; and

Fig.1 PRIOR ART

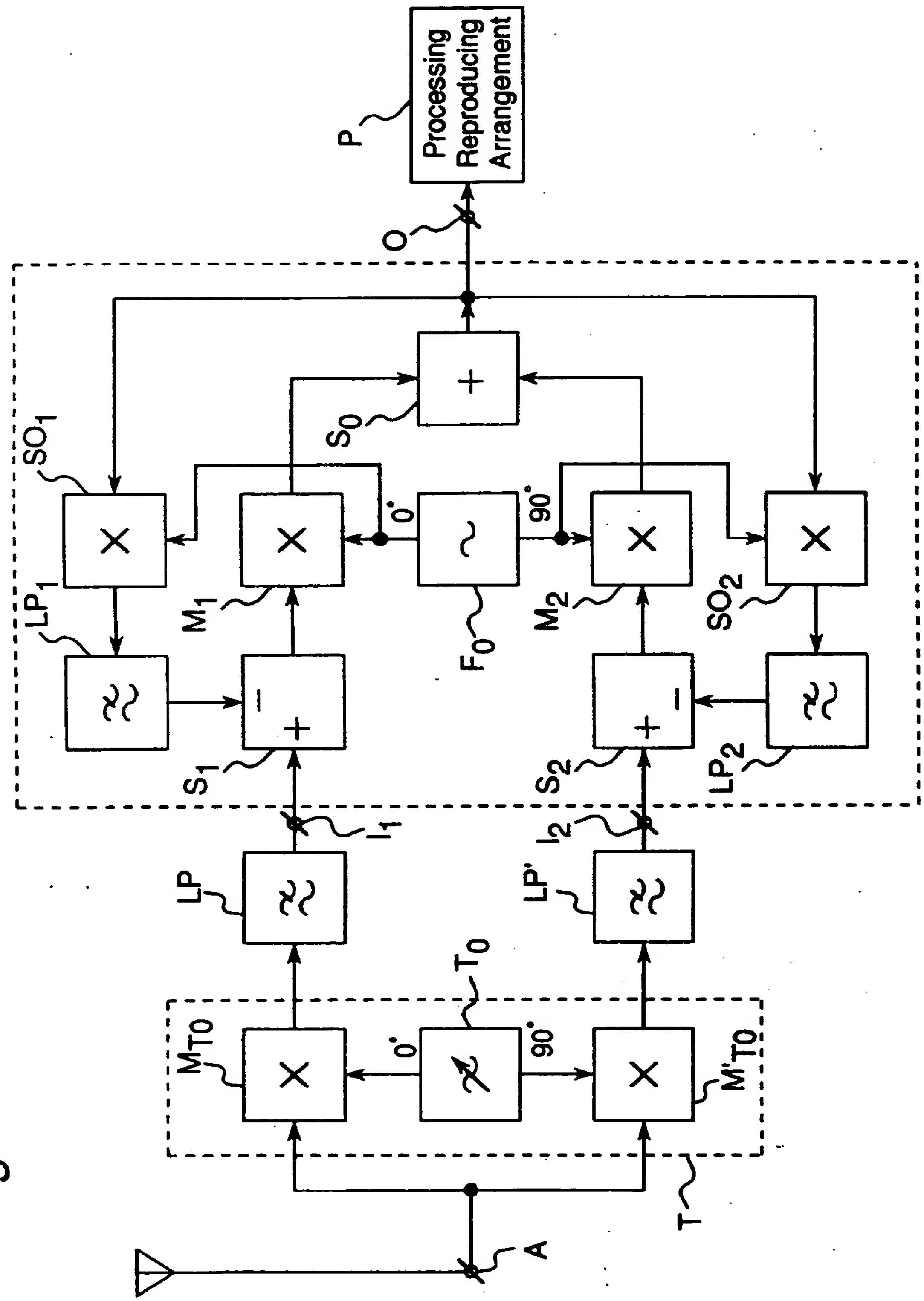
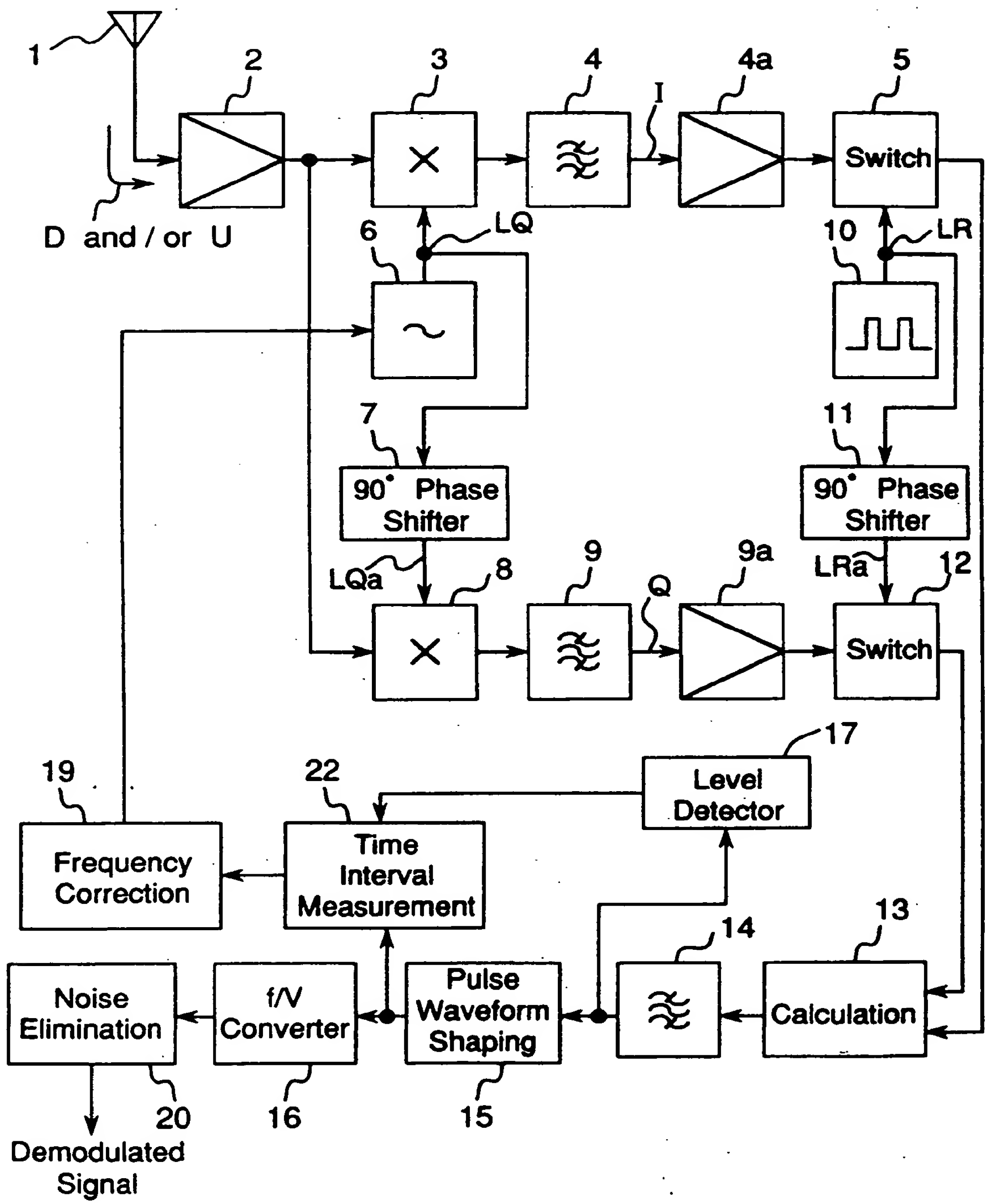


Fig.3


1
2
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I
Switch
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6
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90° Phase Shifter
90° Phase Shifter
LQa
8
9
9a
Q
LRa
12
Switch
17
Level Detector
19
22
Frequency Correction
Time Interval Measurement
13
14
Noise Elimination
f/V Converter
Pulse Waveform Shaping
Calculation
20
16
15
Demodulated Signal

Fig.5

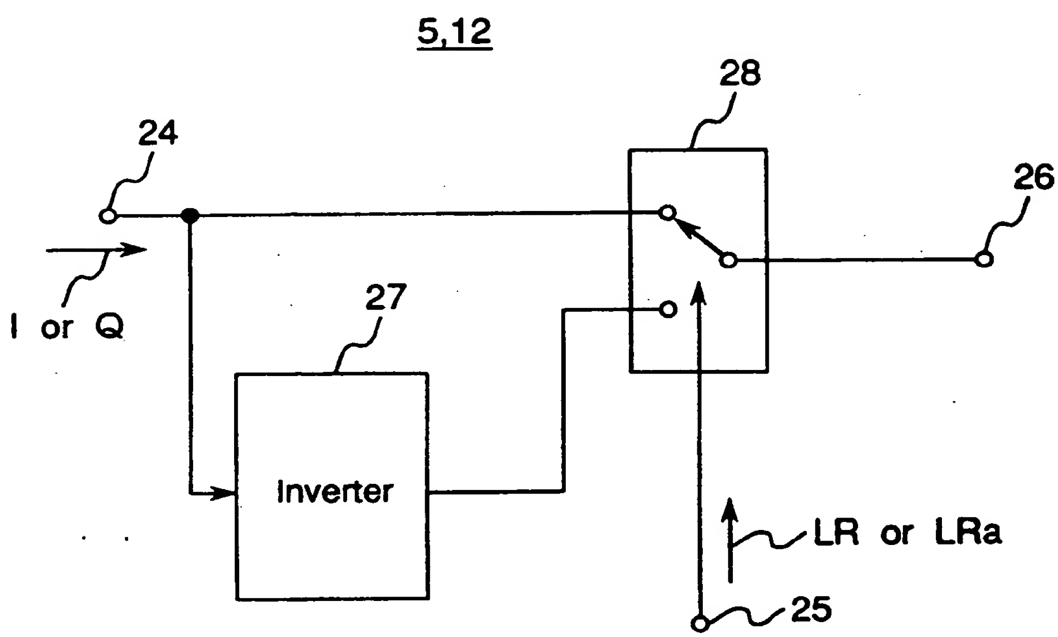


Fig.7

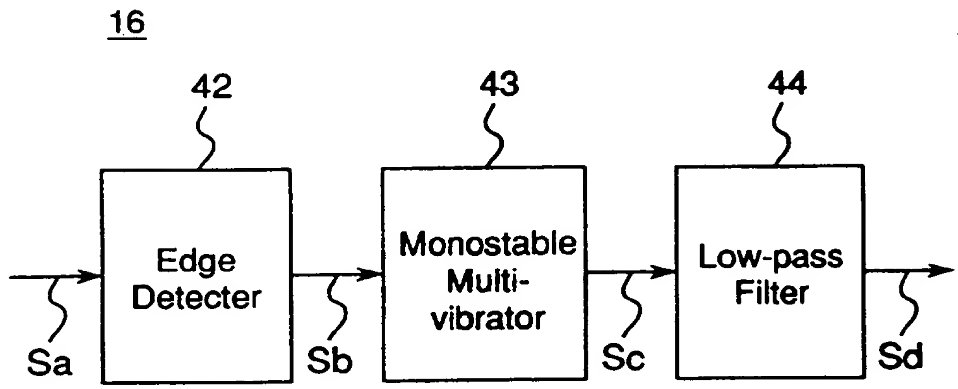

16
42
43
44
Edge Detecter
Monostable Multi-vibrator
Low-pass Filter
Sa
Sb
Sc
Sd

Fig.8

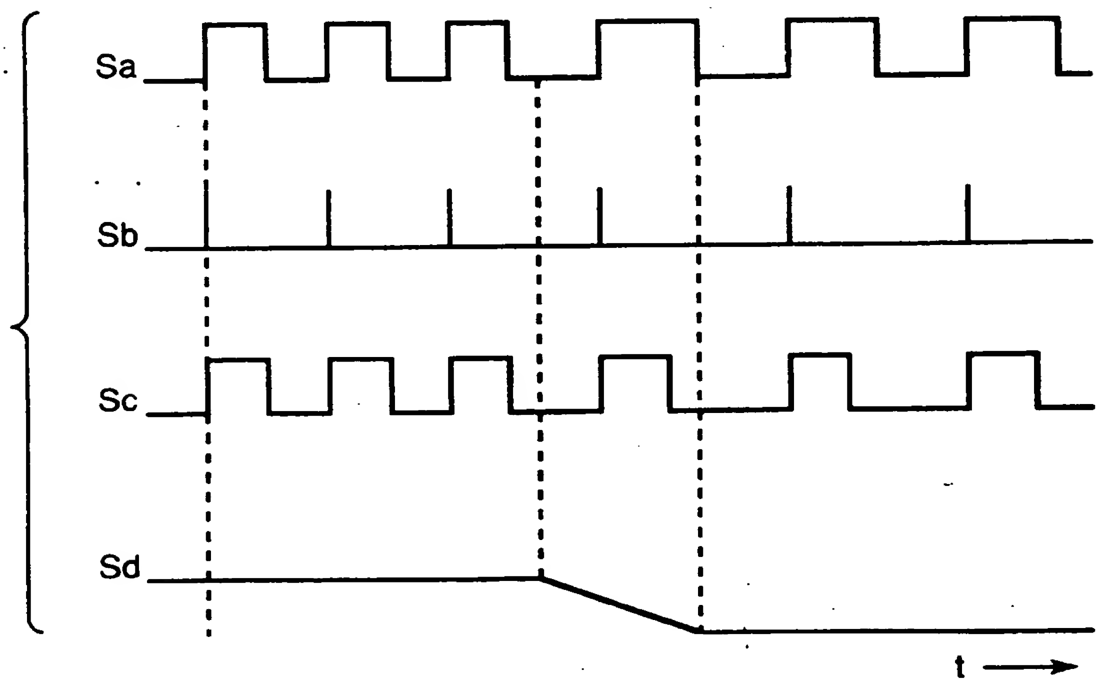

Sa
Sb
Sc
Sd
t

Fig.10 Prior Art

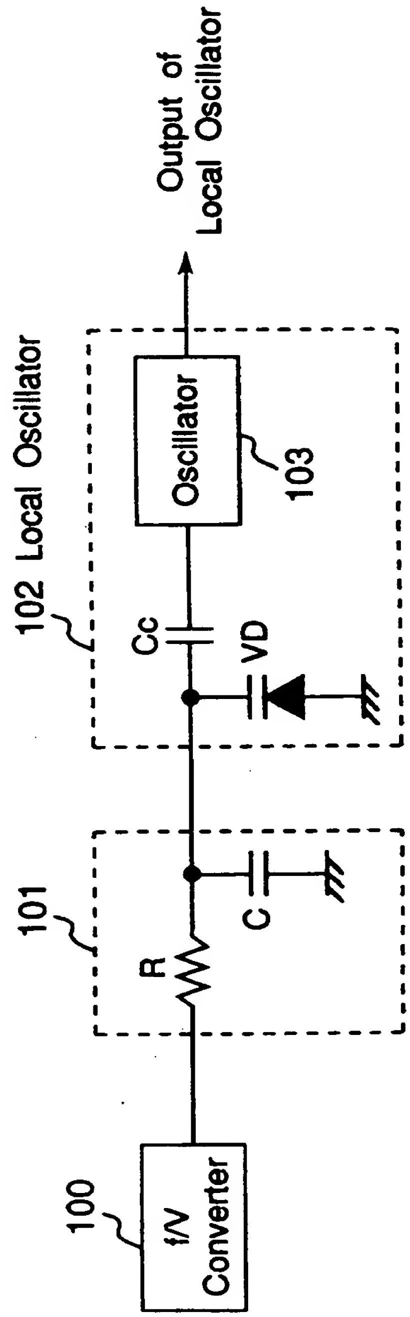
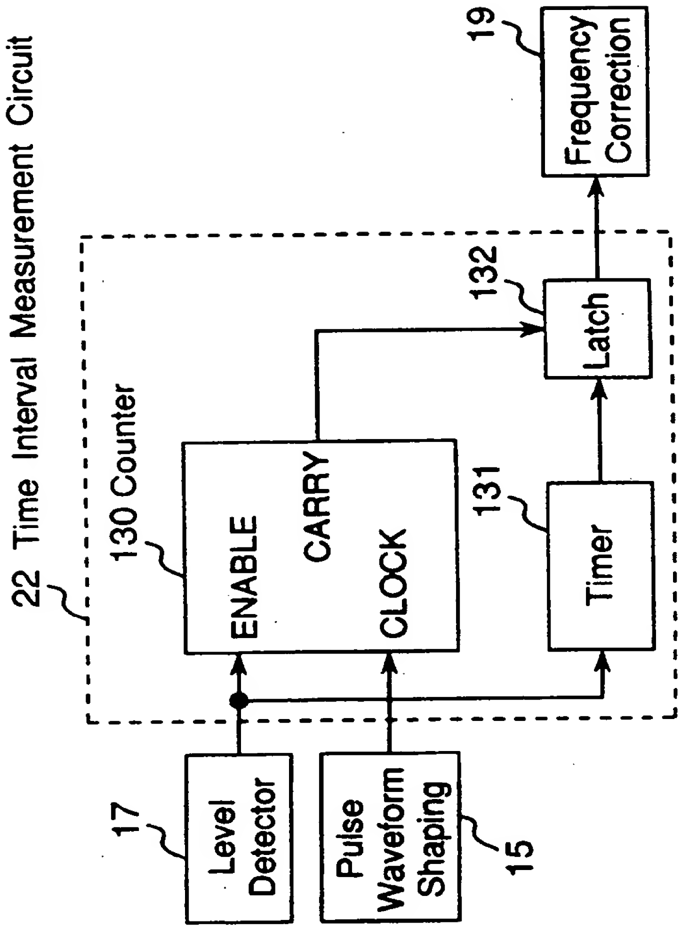


Fig.12


22 Time Interval Measurement Circuit
130 Counter
ENABLE
CARRY
CLOCK
131
Timer
132
Latch
19
Frequency Correction
17
Level Detector
Pulse Waveform Shaping
15

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 10 0652

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	GB-A-2 137 836 (MULTITONE ELECTRONICS PLC) * abstract; figure 2 *	1	H03J7/02 H03D3/00
A	PATENT ABSTRACTS OF JAPAN vol. 9 no. 208 (E-338) [1931] ,24 August 1985 & JP-A-60 072454 (NIPPON DENSHI DENWA KOSHA) 24 April 1985, * abstract *	1	
A	EP-A-0 526 836 (KABUSHIKI KAISHA TOSHIBA) * abstract; figure 1 *	1	
A	PATENT ABSTRACTS OF JAPAN vol. 10 no. 20 (E-376) [2077] ,25 January 1986 & JP-A-60 182205 (FUJITSU K.K.) * abstract *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
H03J
H03D
H04L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 June 1995	Peeters, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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& : member of the same patent family, corresponding document

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